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Controlling the instabilities along a 3DVar analysis cycle by assimilating in the unstable subspace: a comparison with the EnKF

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A feature that is essential for the success of assimilation methods is that they properly take into account the temporal evolution of the uncertainty on the state of the flow, and in particular the uncertainty that results from the development of instabilities. The method of 'Assimilation in the Unstable Subspace' (AUS) directly tracks the unstable modes of the assimilation system by breeding on the data assimilation system (BDAS). This method finds its natural application in an adaptive observational framework, where a small number of unstable vectors and of adaptive observations is sufficient to control the system. In the present study, the added value of AUS in a fixed observational configuration is investigated.

Observation system simulation experiments are performed in the context of a quasi-geostrophic atmospheric model with a fixed network of observations. AUS is implemented in combination with a 3DVar analysis cycle, while parallel experiments are performed with 3DVar and with a variable ensemble size EnKF.

Results indicate that, when AUS is used the analysis error is significantly reduced and in particular the error spikes present in the pure 3DVar analysis cycle are systematically eliminated. Experiments with the EnKF show that to obtain a similar performance a sufficiently large number of ensemble members is needed.

This study demonstrates that, at least in the idealized context of a quasi-geostrophic model, a significant improvement of a statistically based (3DVar) assimilation can be obtain by AUS at a lower computational cost than an EnKF.